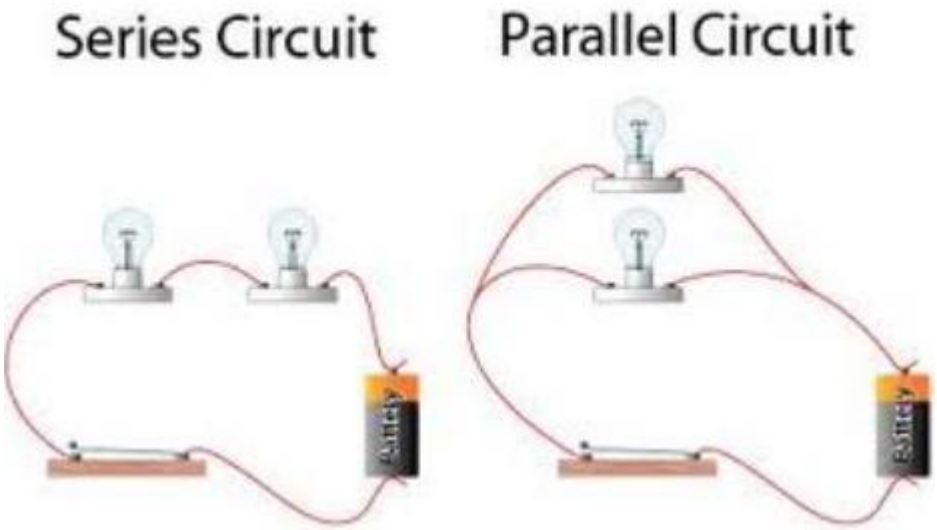
Name(s) _____ Hr. ____
Parallel Circuits Using PHET

We said that there were two ways to hook up devices like light bulbs and resistors into circuits. We studied SERIES circuits earlier. In a series circuit, we force the charge to flow along one pathway only. The charge flow (current) as determined by a ammeter is the same everywhere in the pathway as is related to the total or equivalent resistance (Req). If the total resistance (Req) is high, then there will be little current flow. The higher the total resistance, the less current. Each device in a series circuits 'consumes' some of the voltage. We called this the VOLTAGE DROP. The voltage drop across a light bulb (or other resistor) is based the resistance of the device.

On the other hand, parallel circuits have more than one pathway for the charge to flow. These pathways are called BRANCHES. The places where the current will split are called NODES or JUNCTIONS. It turns out that things (current, voltage, and Req) are all much different in a parallel circuits.

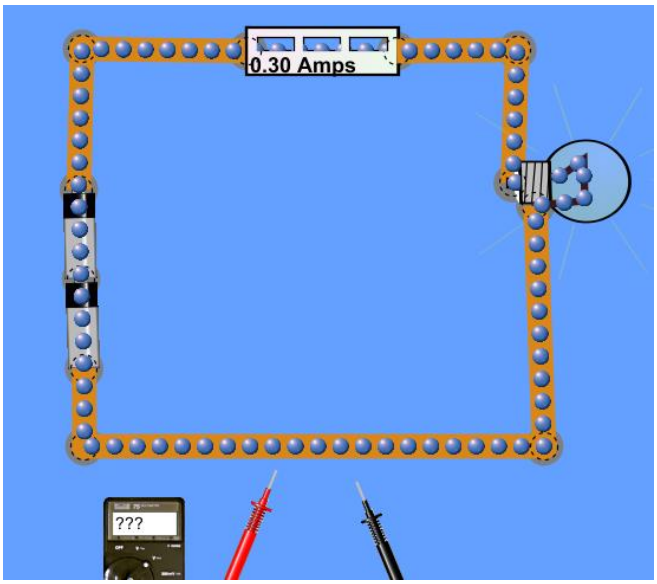


Step 1. Open up your phet circuit simulation (Circuit Construction Kit (DC Only), Virtual Lab: http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc-virtual-lab)

Make sure to open up the correct simulation.

The answers are at the end.

Step 2. Let's build our first circuit. This will be our baseline circuit. Build your basic one resistor circuit (Use 2 batteries, each 1.5 V, one light bulb with a resistance of 10 Ohms. Make sure to put in an ammeter and use a voltmeter to check your batteries' voltage (3V) and your light bulb voltage.



a) Current leaving the batteries as measured by your ammeter = _____ amps.
b) Voltage across the light bulb = _____ Volts

Step 3. Let's build our second circuit. Watch the video as I do it. Let's build a two resistor circuit with two light bulbs in parallel. Again, 2 batteries, each 1.5V, two light bulbs each with a resistance of 10 Ohm. Keep the one ammeter there before the node and then put in an ammeter to measure the current through each branch. We will use a voltmeter to measure the voltage drop around each light bulb and around both light bulbs.

After you get the circuit built, use it to answer the questions

a) What happened the current delivered by the batteries as shown on the ammeter present in the circuit before the node (compared to the baseline circuit)?
_____

b) Isn't this much different than what we saw with series circuits when we added a second light bulb in series? What happened to the current delivered by the batteries compared to the baseline circuit (go back and look at your series with phet document, if needed.)
_____

c) What did the current do at the top node? What did the current do at the bottom node?
_____

d) If we sum of the two branch currents, what value do we get? What does the sum of the branch current =?
_____

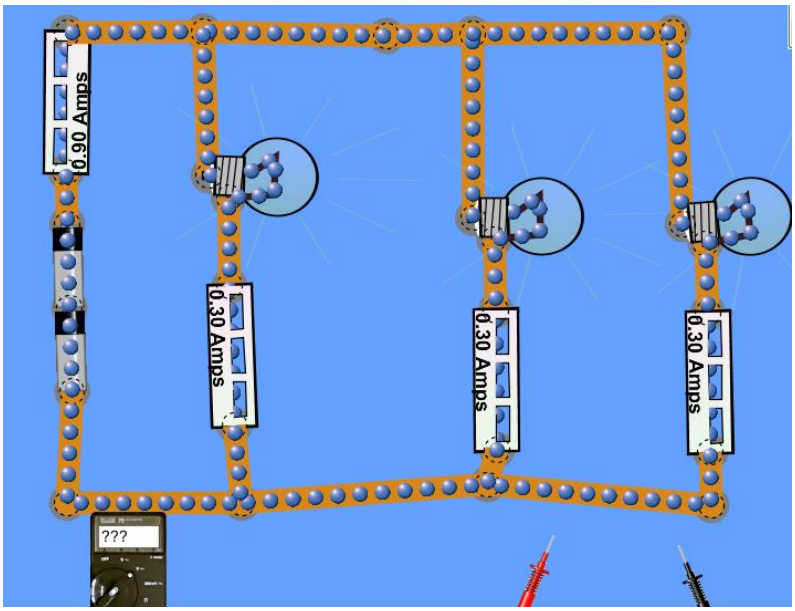
e) In the series circuit, we had voltage drops. The sum of the voltage drops = the voltage supplied by the batteries. Is this parallel circuit, we don't see this. What instead is the voltmeter reading around each light bulb?
_____

f) Let's go back to the overall current delivered by the batteries (part a and b above). In a series circuit the overall circuit's current dropped when we added light bulbs. We explained this by noting that we are

adding resistance (friction). What we see now with the parallel circuit is that the current increased when we added a second light bulb now. How might we explain this result with resistance? How can our current be going up now with a parallel circuit?

_____

Step 4. Let's build our third circuit. Watch the video as I do it. Let's build a three resistor circuit with three light bulbs in parallel. Again, 2 batteries, each 1.5V, three light bulbs each with a resistance of 10 Ohm. Keep the one ammeter there before the node and then put in an ammeter to measure the current through each branch. We will use a voltmeter to measure the voltage drop around each light bulb and around both light bulbs.



a) What is going on with the overall battery current as compared to the first two circuits?

_____

b) What is going on with the branch currents as documented by the branch ammeters?

_____

c) Does the branch currents still sum to = the overall current delivered by the batteries?

_____

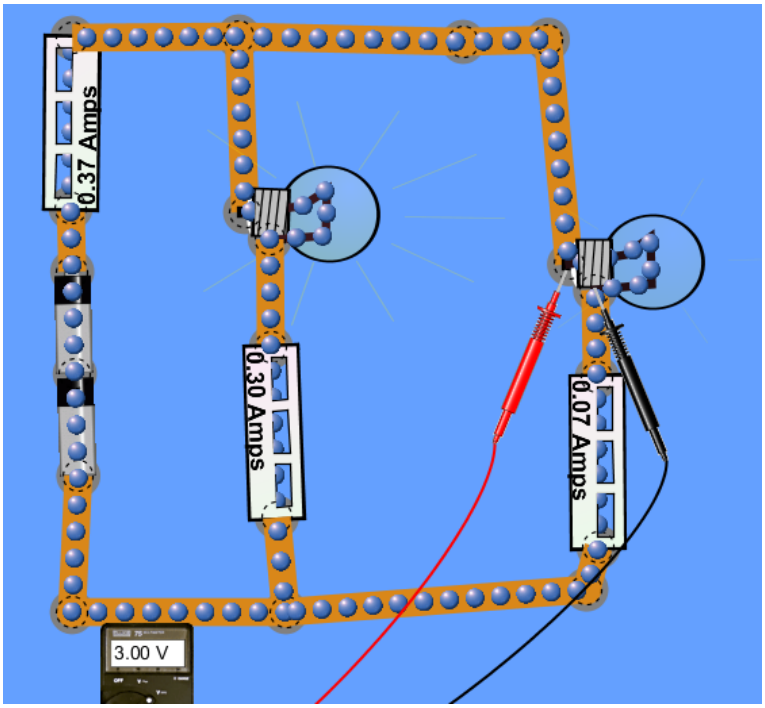
d) What about the voltage 'drops' now when you place the voltmeter across each light bulb separately?

_____

e) Explain how the overall current (part a) could decrease in terms of equivalent resistance (see f on the previous circuit's questions.) What must be happening to the equivalent resistance?

_____

Step 5: Building our fourth circuit. Two light bulbs in parallel: one 10 Ohm Light bulb and the other a 40 Ohm light bulb (this matches one round bulb and one long bulb). Again, use 2 batteries for a total of 3 V. Measure the current from the batteries and each branch current with three total ammeters. Also measure the voltages (around the batteries and around each light bulb).



a) Does the branch currents still add up the overall current supplied by the batteries?

b) Do both light bulbs get the same amount of current?

c) Explain your answer to the previous question using the ideas of resistance.

d) In the previous circuits, each light bulb had the same push (voltage). Is this still true?

e) Why is one light bulb brighter than the other? (Hint, think about the power equation, P = VI)

Answers

First circuit:

a) Current leaving the batteries as measured by your ammeter = 0.3 amps.
b) Voltage across the light bulb = 3 Volts

Second circuit: Two 10 Ohm light bulbs in parallel

a) What happened the current delivered by the batteries as shown on the ammeter present in the circuit before the node (compared to the baseline circuit)?

The current has increased from the baseline. It has doubled.

b) Isn't this much different than what we saw with series circuits when we added a second light bulb in series? What happened to the current delivered by the batteries compared to the baseline circuit (go back and look at your series with phet document, if needed).

This is much different than we saw in a series circuit. In the series circuit, the current pushed around the pathway by the batteries DROPPED when we added a second light bulb. NOW, we see the current is INCREASING when we added a second light bulb in parallel.

c) What did the current do at the top node? What did the current do at the bottom node?

The current split into equal parts, part of it going down the one branch and the other part going down the second branch. It recombines at the bottom node.

d) If we sum of the two branch currents, what value do we get? What does the sum of the branch current =?

The two branch currents added together = current delivered by the batteries.

e) In the series circuit, we had voltage drops. The sum of the voltage drops = the voltage supplied by the batteries. Is this parallel circuit, we don't see this. What instead is the voltmeter reading around each light bulb?

The branch voltages are now = voltage from the batteries. There are no 'drops' in voltage. Each light bulb gets the same push!

f) Let's go back to the overall current delivered by the batteries (part a and b above). In a series circuit the overall circuit's current dropped when we added light bulbs. We explained this by noting that we are adding resistance (friction). What we see now with the parallel circuit is that the current increased when we added a second light bulb now. How might we explain this result with resistance? How can our current be going up now with a parallel circuit?

In a series circuit adding a light bulb INCREASED the equivalent or total resistance. In a parallel circuit adding a light bulb DECREASED the equivalent or total resistance. We must be decreasing the overall effective resistance. This is most interesting! By decreasing the overall equivalent resistance, our current increases as delivered by the batteries. We can show this with Ohm's Law (V = IR); if our R goes DOWN, our I must go UP, given a constant voltage.

Third circuit: Three 10 Ohm Light bulbs in parallel

a) What is going on with the overall battery current as compared to the first two circuits?

   Increased. Now it is 0.9 Amps.

b) What is going on with the branch currents as documented by the branch ammeters?

   The branch currents are all 0.3 Amps. This is the same as before.

c) Does the branch currents still sum to = the overall current delivered by the batteries?

   Yes: 0.3 Amps + 0.3 Amps + 0.3 Amps = 0.9 Amps = current delivered by the batteries

d) What about the voltage 'drops' now when you place the voltmeter across each light bulb separately?

   Each light bulb shows a voltage of 3 Volts. There is no change from the previous circuit. Each light bulb gets = pressure and the pressure = to that provided by the batteries.

e) Explain how the overall current (part a) could decrease in terms of equivalent resistance (see f on the previous circuit's questions.) What must be happening to the equivalent resistance?

   For the current to increase, the equivalent resistance must be decreasing. As mentioned on part f: By decreasing the overall equivalent resistance, our current increases as delivered by the batteries. We can show this with Ohm's Law (V = IR); if our R goes DOWN, our I must go UP, given a constant voltage.

Fourth circuit: Two light bulbs in parallel, one 10 Ohms and the other 40 Ohms

a) Does the branch currents still add up the overall current supplied by the batteries?

   Yes

b) Do both light bulbs get the same amount of current?

   No

c) Explain your answer to the previous question using the ideas of resistance.

   When the light bulbs were identical (all 10 Ohms), each get the same current and are the same brightness. Now that one light bulb has more resistance, there is more effective resistance in that branch and less current flows through that branch.

d) In the previous circuits, each light bulb had the same push (voltage). Is this still true?

   Yes, each light bulb still has 3 Volts of pressure. This doesn't change and is one of the basics of parallel circuits: each device receives the same push (electrical pressure or voltage)

e) Why is one light bulb brighter than the other? (Hint, think about the power equation, P = VI)

   Power is V times I. Both light bulbs have the same voltage (3V); however, the light bulb that is 40 Ohm has much less current going through it. Consequently, there it is consuming much less power than the other light bulb (10 Ohm one). The 10 Ohm light bulb consumes more power and is brighter!